NO. SU2
SEPTEMBER 1956

JOURNAL of the

Surveying and Mapping Division

PROCEEDINGS OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS

VOLUME 82

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3. The manuscript (a ribbon copy and two copies) should be double-spaced on one side of 8½-in. by 11-in. paper. Papers that were originally prepared for oral presentation must be rewritten into the third person before being submitted.

4. The author's full name, Society membership grade, and footnote reference stating present employment should appear on the first page of the paper.

5. Mathematics are reproduced directly from the copy that is submitted. Because of this, it is necessary that capital letters be drawn, in black ink, 3/16-in. high (with all other symbols and characters in the proportions dictated by standard drafting practice) and that no line of mathematics be longer than 6½-in. Ribbon copies of typed equations may be used but they will be proportionately smaller in the printed version.

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7. Illustrations should be drawn in black ink on one side of 8½-in. by 11-in. paper within an invisible frame that measures 6½-in. by 10½-in.; the caption should also be included within the frame. Because illustrations will be reduced to 69% of the original size, the capital letters should be 3/16-in. high. Photographs should be submitted as glossy prints in a size that is less than 6½-in. by 10½-in. Explanations and descriptions should be made within the text for each illustration.

8. Papers should average about 12,000 words in length and should be no longer than 18,000 words. As an approximation, each full page of typed text, table, or illustration is the equivalent of 300 words.

Further information concerning the preparation of technical papers is contained in "Publication Procedure for Technical Papers" (Proc. Paper 290) which can be obtained from the Society.

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AT,BD,CP,CO,HW,IR,SU,WW.

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SURVEYING AND MAPPING DIVISION
Proceedings of the American Society of Civil Engineers

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COORDINATED SURVEYING AND MAPPING FOR INDUSTRY

E. D. Morse,[1] M. ASCE
(Proc. Paper 1064)

SYNOPSIS

The lasting economies and many advantages that derive from utilization of a plane coordinate system in surveying and mapping are generally acknowledged by civil engineers and land surveyors at this time although the employment of such systems, particularly in industry, is by no means as widespread as is justified. The rapid expansion of industry during the past few years and the need for greater precision and efficiency in surveying and mapping operations, together with the availability of an increasing number of accurate and permanent control points keyed to the State Plane Coordinate Systems, gives added emphasis to this matter.

INTRODUCTION

A good part of the reluctance of industry to adopt the use of State Plane Coordinates no doubt stems from a mistaken idea of the complexity and cost involved relative to the lasting benefits that can be derived. The experience of a public utility company in Houston, Texas and the solution through trial and error over an extended period of its rather formidable mapping problem is cited here as a case in favor of the early adoption of State Plane Coordinates by industries and others with related requirements for extensive map coverage.

Early Mapping Efforts of a Houston Utility

When Houston, Texas and the contiguous area began experiencing an accelerated rate of industrial and residential growth some 30 years ago, Houston Lighting and Power Company was confronted with a serious mapping problem. No large scale maps of dependable accuracy were available and either such maps needed to be provided or recourse had, to an ever increasing extent, to

Note: Discussion open until February 1, 1957. Paper 1064 is part of the copyrighted Journal of the Surveying and Mapping Division of the American Society of Civil Engineers, Vol. 82, No. SU 2, September, 1956.

1. Supt. of Civ. Eng., Houston Lighting and Power Co., Houston, Tex.

field measurements for such simple and routine matters as line extension estimates, inventories, and betterment rebuilds. During the early stages of the expansion a compromise was managed whereby operating maps that were more nearly diagrams than properly scaled drawings were used in combination with rough field measurements for cost estimates of customer extensions. This proved to be both time-consuming and poor public relations from the standpoint of providing adequate and efficient customer service in a rapidly growing urban area.

An attempt was made in the late 1920's to compile large scale maps of dependable accuracy by assemblying subdivision plats and tying them together at uniform scales with the aid of all available city, county, pipe line, and railroad alignment maps. It was found that these maps could not be fitting together with any degree of success without first making extensive field ties. So many large discrepancies were discovered in the data obtained from other sources and such large areas were found to be lacking altogether in alignment ties that a system of coordinated control traverses was undertaken on a small scale, experimental basis in 1931.

In the accomplishment of the initial control work a local origin for the coordinates was devised and the field work was performed with ordinary unstandardized tapes and one-minute transits. Two or three Polaris observations were made per square mile of area to hold in bounds the angular alignment of the traverses. It was found that this method was very satisfactory for mapping areas of limited extent but that discrepancies of considerable magnitude tend to accumulate in covering an expanse of a hundred or more square miles. Also, with the City developing rapidly around its perimeter, needed mapping could not be undertaken in widely separated areas without entailing long delays for traverse loops. A careful study was made of the literature then available that dealt with the problem of dense urban survey control and it was found that A.S.C.E. Manual No. 10, "Technical Procedure for City Surveys," published in 1934, contained the most detailed and comprehensive treatment of the subject. It was decided to undertake a system of high order triangulation and join it rigidly with a network of primary traverses as a means of controlling the lower order traverses used in the mapping proper.

Urban Survey Control Project by Local Means

During 1938 and 1939 the Company's engineering personnel executed a triangulation network comprising 25 occupied stations that were distributed over some 200 square miles of metropolitan Houston. Procedures for first-order urban triangulation outlined in A.S.C.E. Manual No. 10 were followed as closely as the equipment available to the Company would permit. Two base lines were measured with first-order precision and a minimum of 6 sets of 6 direct and 6 reverse repetitions were turned at each angle with a 10-second repeating theodolite. The work covered by this project is delineated by light weight lines in Figure 1.

A great amount of difficulty was experienced with triangle closures due mainly to the fact that work had to be performed during the daytime and without benefit of stable instrument footing at several of the stations. After a considerable amount of rechecking of the angles which were involved in excessive triangle closures, a check between bases of 1:47,000 was obtained

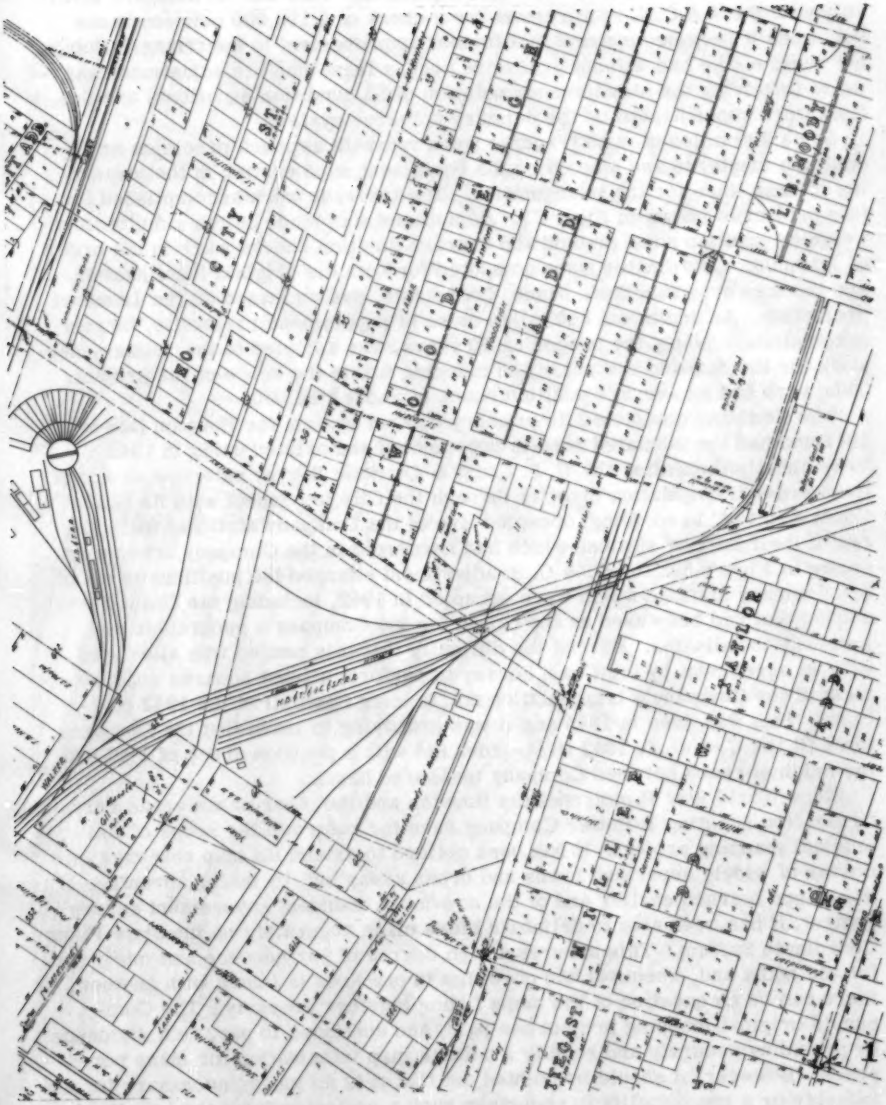

Figure 1.

after adjustment of the side and angle equations. This did not compare favorably with the A.S.C.E. requirement for a check of 1:100,000 between bases but, when it became apparent that further improvement to the triangulation net could not be had without excessive cost, a least squares adjustment was made (involving the simultaneous solution of 93 condition equations) and the field work concentrated on the primary traverse system.

Some 200 miles of such traverse were run with as much precision as could be mustered and employing the equipment used earlier in the measuring of base lines for the triangulation. The traverse work accomplished for this project is shown in Figure 2. Adjustment was made by the simultaneous weighted junction point method and average position checks were in the order of 1:18,000. Coordinates were computed for both the original local system and the then available State Plane Coordinate System based on the Lambert projection. An additional 800 miles or so of supplemental traverse, largely accomplished during the preceding 10 years, was adjusted to the primary network for the detailed control of the mapping within the scope of the project. This work had an average position check of about 1:10,000.

The Company completed its primary control system for Houston late in 1941 and had the tabulated results copyrighted and printed early in 1942. Very shortly thereafter the U. S. Coast & Geodetic Survey extended an arc of first-order triangulation directly through the City to connect with its Gulf Coast Arc and, in so doing, occupied five of the Company stations, including two of their earlier stations which had been used in the Company scheme as shown in Figure 1. The C. & G. S. adjustment changed the positions of all of the Company stations which were occupied in 1942, including the Coast Survey station that had been used as the origin for the Company's geographic and Lambert coordinates. Part of the difficulty that this caused was alleviated with an agreement by the Coast Survey to perform a least squares readjustment of the Company's triangulation net, holding fixed all of the 1942 positions. This was done in 1945 and it was gratifying to learn that the Company work fit the C. & G. S. 1942 first-order net with a position check of 1:47,000, the original check between Company measured bases.

Since World War II metropolitan Houston and the other urban areas served by Houston Lighting & Power Company have far outgrown the scope of its original mapping project. It has been obliged to extend its map coverage into dozens of widely separated towns and urban areas but, by taking advantage of the lesson learned earlier and of the now more abundant government survey control, it has been able to delineate these maps accurately on the State Plane Coordinate System. This assures a high degree of permanence and integrity for the maps and, whenever the coverage in one area is joined with another, there can be no question of the maps fitting together properly. The Company's original mapping project has paid, and continues to pay, rich dividends by providing accurate and readily available map information for many purposes. However, it should be pointed out that it is no longer necessary for an industry or a municipality to undertake such a project without the benefit of skilled technical assistance and fully adequate precision equipment.

Legislative Act of 1947

In 1947 Congress authorized the U. S. Coast & Geodetic Survey to cooperate, when requested to do so, with any local governmental agency or

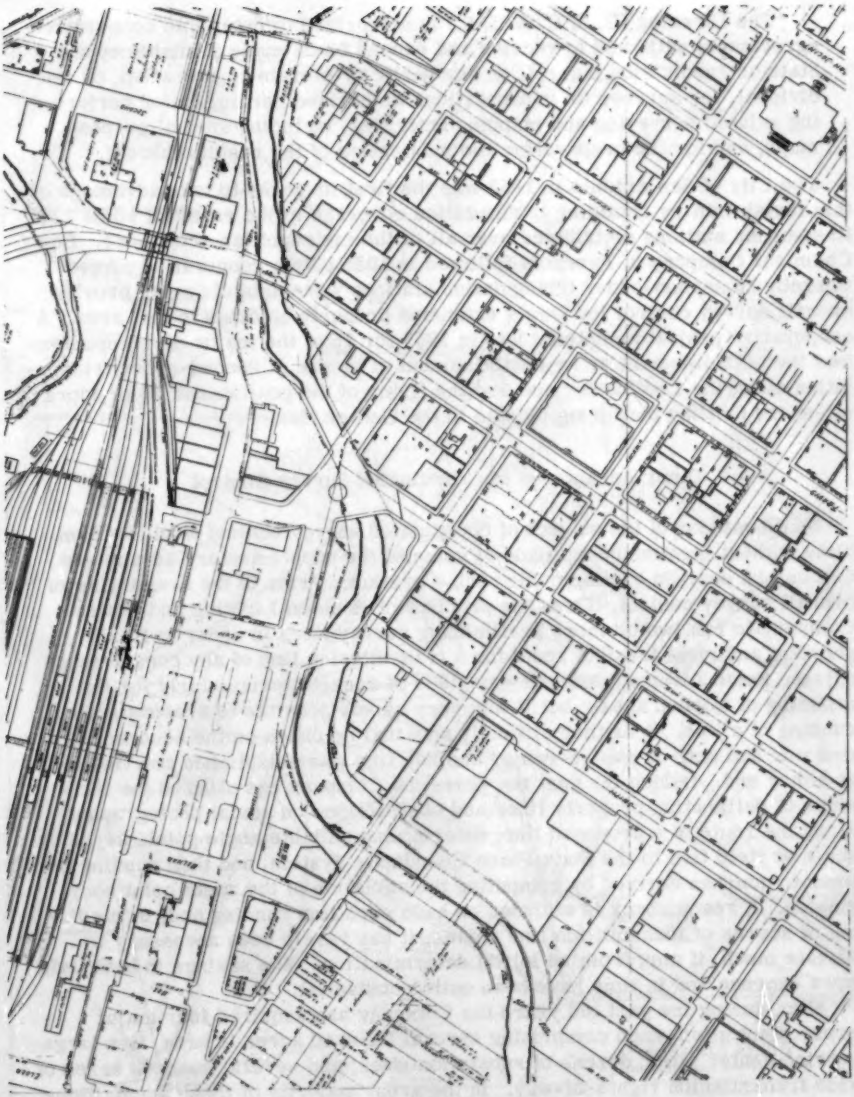

Figure 2.

industry in the performance of survey control projects. The pertinent clause, under Sec. 5 of the Act, reads as follows:

> "The Director (U. S. C. & G. S.) is authorized to enter into cooperative agreements with, and to receive and expend funds made available by any State or subdivision thereof, or any public or private organization, or individual, for surveys or investigations authorized herein, or for performing related surveying and mapping activities, including special purpose maps, and for the preparation and publication of the results thereof."

The City of San Antonio in 1953 was the first in Texas to take advantage of this legislation by obtaining triangulation coverage to the extent of some 125 first-order stations distributed over all of the metropolitan area there. Dow Chemical Company of Freeport followed in 1954 with a cooperative project whereby 18 second-order triangulation stations were established to provide overall survey control for Dow's extensive property holdings in that area. A cooperative project completed late in 1955 for 15 of the major oil companies was the establishment or re-establishment of an arc of second-order triangulation along the Louisiana coast and the fixing of the positions of 20 or more off-shore drilling platforms located in the Gulf of Mexico.

Other Advantages of Coordinated Survey Control

No discussion of the subject of coordinated survey control would be complete without mention being made of some of the supplementary advantages that can be derived by employing such a system. Prior to the availability of overall survey control, it was the practice of Houston Lighting and Power Company to run two or more preliminary survey lines in order to fix the shortest and most feasible route for a transmission line of any considerable extent. Some advantageous use was made of rockets, particularly for the crossing of wooded areas, but it was very rarely possible to accept the first running of a line. A further difficulty was that no check on the accuracy of a line was had until it was re-run or another line was established and tied to it at either end. During the past ten years the Company has utilized the technique of delineating property lines and obstructions on aerial photographs along the route of a proposed line, determining suitable angle points keyed by scale or field ties to the State Plane Coordinate System, and then running the lines to courses derived by computing the variation of the angle point coordinates. A ready check is afforded on each such line running and, in the fixing of scores of transmittion line routes, it has rarely been necessary to deviate much, if any, from an initial determination. The savings in both field work expense and in time have been quite substantial.

Also, during the past ten years the Company has acquired four major power plant sites, each comprising several hundred acres in area, five large service center sites, dozens of substation sites, and several hundred acres of wide transmission rights-of-way. In the great majority of these acquisitions State Plane Coordinates were incorporated in the deed descriptions of the property, thereby making the boundaries of these lands an integral part of the system over-all surveying and mapping control. A specimen copy of such a deep form is shown in Figure 3. During this interval there have been several boundary claims made against the Company, as is no doubt the case with most large land owners. Fortunately, its extensive and well coordinated ties to

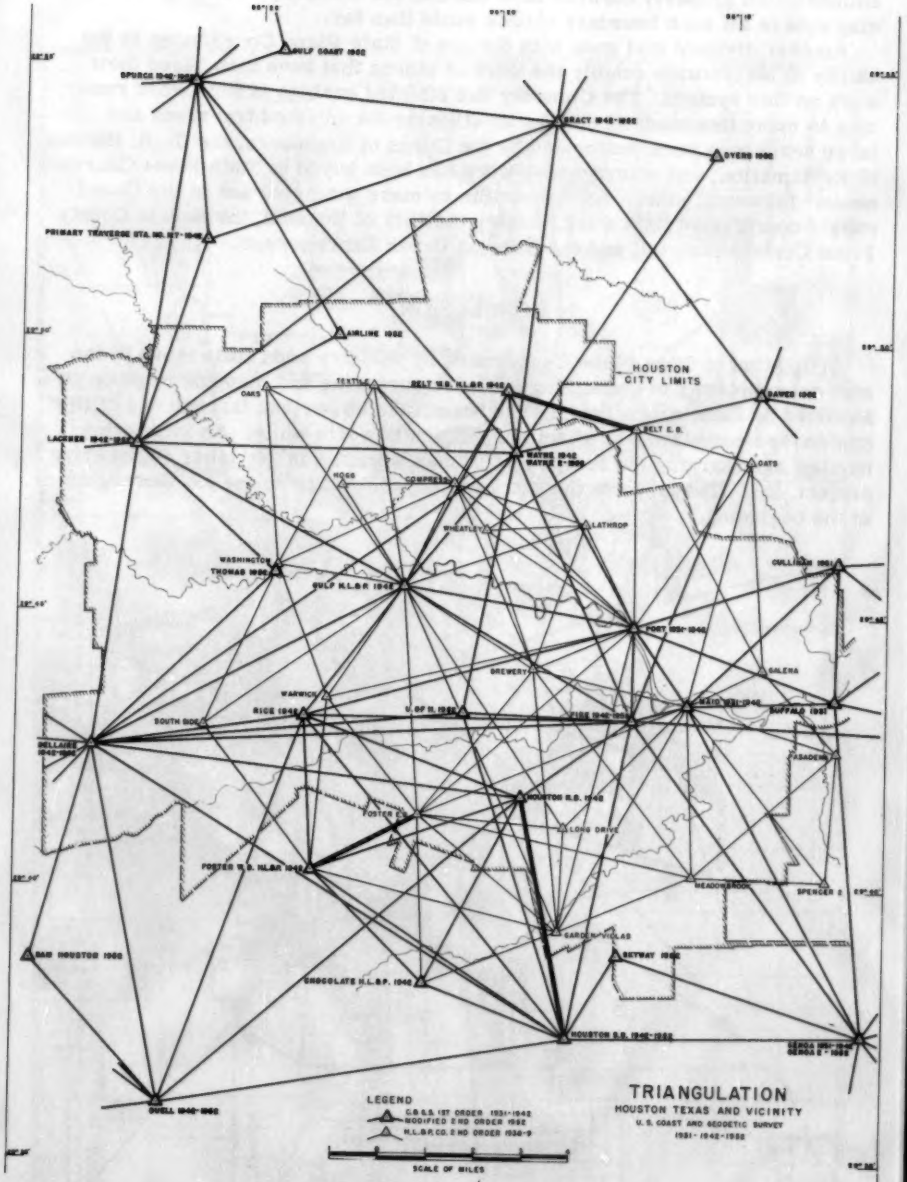
HOUSTON
CITY LIMITS
TRIANGULATION
HOUSTON TEXAS AND VICINITY
U. S. COAST AND GEODETIC SURVEY
1931 - 1942 - 1952
LEGEND
SCALE OF MILES

Figure 3.

authenticated property corners have enabled the Company to stay on the winning side of all such boundary claims made thus far.

Another divident that goes with the use of State Plane Coordinates is the ability to incorporate readily the work of others that have also based their work on this system. The Company has effected savings in field work running to many thousands of dollars by utilizing the adjusted traverses and large scale map work performed by the Corps of Engineers, the U. S. Bureau of Reclamation, and others whose work has been keyed to State Plane Coordinates. Likewise, others have been able to make extensive use of the Company's coordinated field work, notably the City of Houston, the Harris County Flood Control District, and the Houston Urban Expressways.

CONCLUSION

Utilization of State Plane Coordinates by industry adds little more to the cost or complexity of conducting ordinary surveying and mapping work on an assumed or local origin basis. The benefits to be derived through use of this system are cumulative in effect and eminently worth while. An increasing number are learning the lesson that in map work, as in any other engineering project, it is always worth the extra effort required to do the job thoroughly in the beginning.

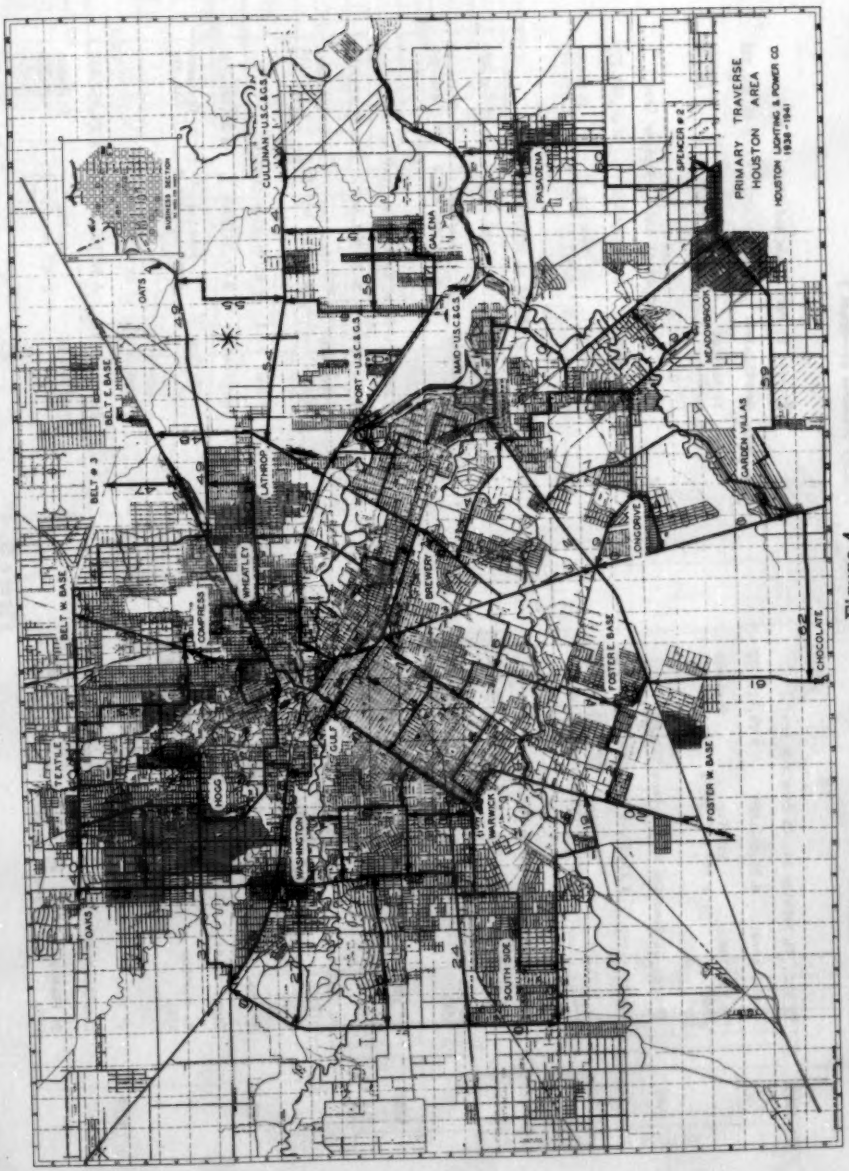
PRIMARY TRAVERSE
HOUSTON AREA
HOUSTON LIGHTING & POWER CO
1938 - 1941
SPENCER # 2
PASADENA
GALENA
CULLMAN - U.S.C.&G.S.
MAD - U.S.C.&G.S.
PORT - U.S.C.&G.S.
MEADOWBROOK
GARDEN VILLAS
LONGDRIVE
FOSTER E BASE
FOSTER W BASE
CHOCOLATE
BREWERY
WHEATLEY
LATHROP
COMPRESS
BELT W BASE
BELT E BASE
BELT # 3
OATS
HOGG
WASHINGTON
GULF
WARWICK
SOUTH SIDE
OAKS

Figure 4.

Primary Traverse #11--Sheet 2.

1465	¾" rod, CL Berkley and CL Scanlock (ref.)		
	Coordinates:	S 21,250.824	E 24,419.737
	To Station	Bearing	Distance
	1466	N 88° 28' 36" E	834.831
1466	¾" rod, CL Scanlock and CL Fennell (ref.)		
	Coordinates:	S 21,228.629	E 25,254.273
	To Station	Bearing	Distance
	1467	N 88° 28' 36" E	880.271
1467	Anchor bolt, RL Scanlock and CL Broadway.		
	Coordinates:	S 21,205.226	E 26,134.234
	To Station	Bearing	Distance
	478d	S 01° 27' 21" E	1,565.295
478d	¾" rod, CL Broadway and CL Park Terrace (ref.)		
Tie to P.T. #10	Coordinates:	S 22,770.016	E 26,174.005
	To Station	Bearing	Distance
	472	N 89° 21' 46" E	2,371.781
	478c	S 01° 27' 21" E	914.236
478c	¾" rod, CL Broadway and CL Kimble.		
	Coordinates:	S 23,683.957	E 26,197.234
	To Station	Bearing	Distance
	478b	S 01° 27' 21" E	949.032
478b	1" rod, CL Broadway and CL Detroit.		
	Coordinates:	S 24,632.683	E 26,221.346
	To Station	Bearing	Distance
	478a	S 88° 33' 01" W	18.254

Primary Traverse #9--Sheet 3.

467a	¾" rod, RL Park Place and CL G. N. R.		
Junction P.T. #11	Coordinates:	S 28,331.057	E 26,300.982
	To Station	Bearing	Distance
	1148	N 88° 37' 16" E	67.256
1148	¾" rod, RL Park Place and RL Winkler (ref.)		
	Coordinates:	S 28,329.438	E 26,368.219
	To Station	Bearing	Distance
	1149	S 40° 42' 34" E	1,935.645
1149	¾" rod, P. C. of RL Winkler (ref.)		
	Coordinates:	S 29,796.712	E 27,630.689
	To Station	Bearing	Distance
	1150	S 46° 40' 20" E	286.567
1150	¾" rod, P. T. of RL Winkler (ref.)		
	Coordinates:	S 29,993.345	E 27,839.149
	To Station	Bearing	Distance
	1151	S 40°42' 43" E	1,514.115
1151	¾" rod, P. I. of RL Winkler (ref.)		
	Coordinates:	S 31,141.044	E 28,826.738
	To Station	Bearing	Distance
	1152	S 75° 42' 26" E	645.736
1152	¾" rod, P. I. of RL Winkler (ref.)		
	Coordinates:	S 31,300.461	E 29,452.488
	To Station	Bearing	Distance
	1144	S 40° 41' 06" E	418.233

Figure 5.


BRAEBURN TERRACE NO. 1
BRAEBURN TERRACE SEC. 2ND REPLAT
BRAEBURN TERRACE SEC. 2ND
SHOPPING CENTER
BRAE ORCHARDS
BONNIE ORANGE
ACRES
BONHAM
4-D

Figure 6.

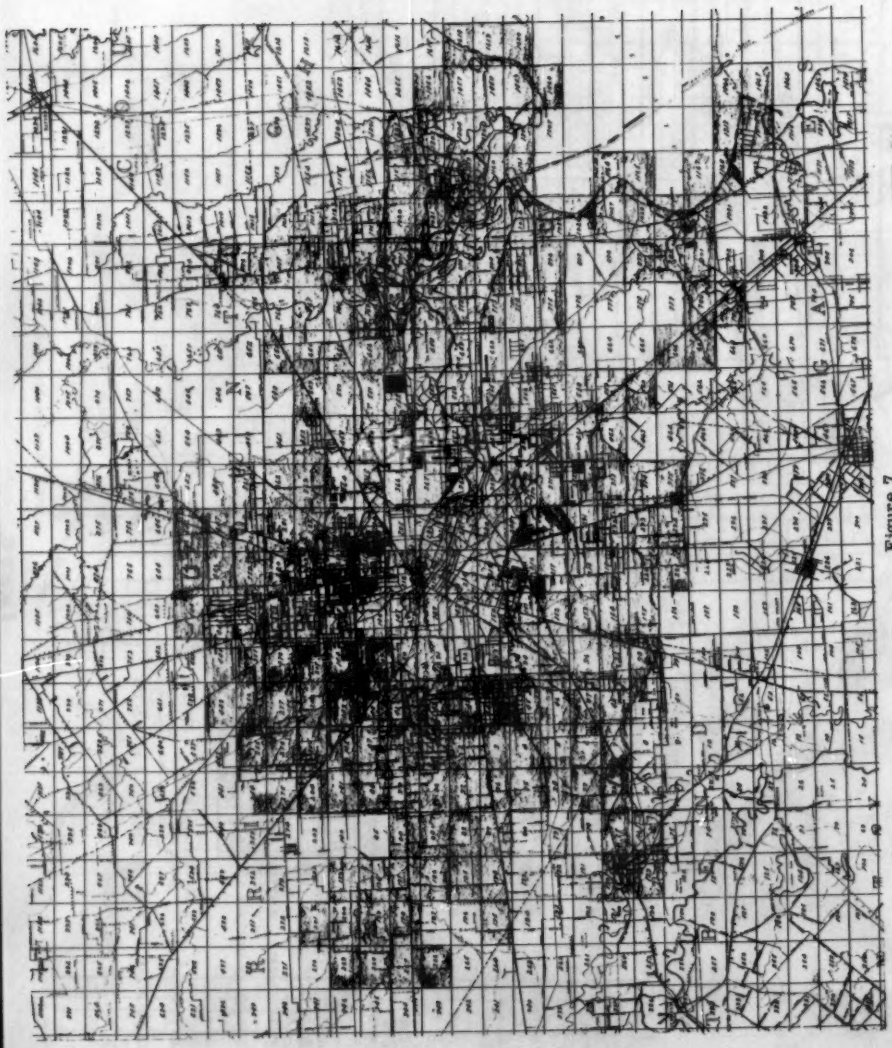

Figure 7.

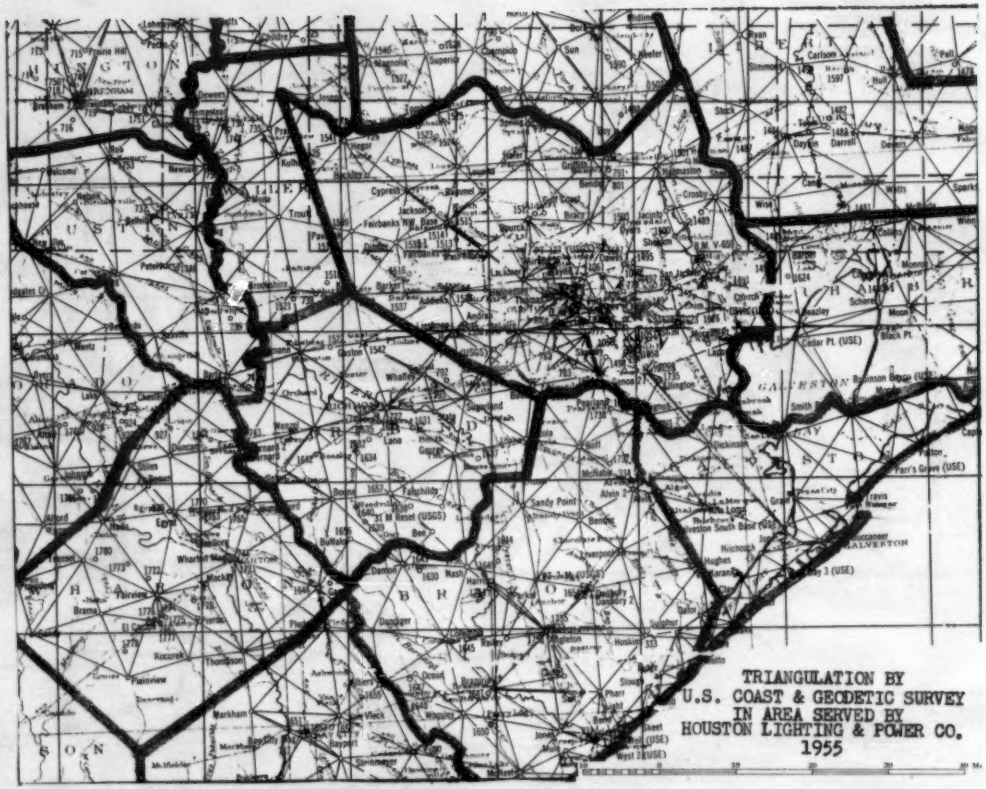
TRIANGULATION BY
U.S. COAST & GEODETIC SURVEY
IN AREA SERVED BY
HOUSTON LIGHTING & POWER CO.
1955

Figure 8.

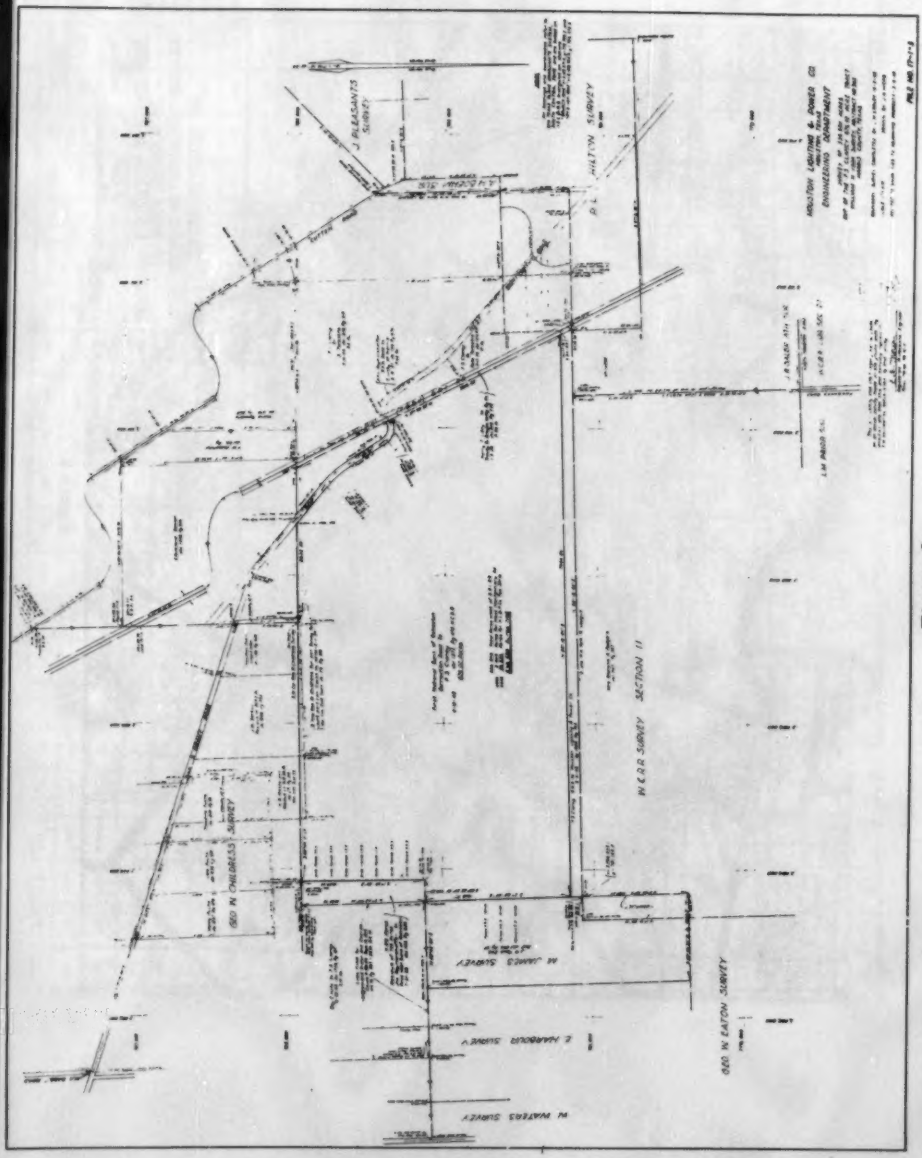

Figure 9.

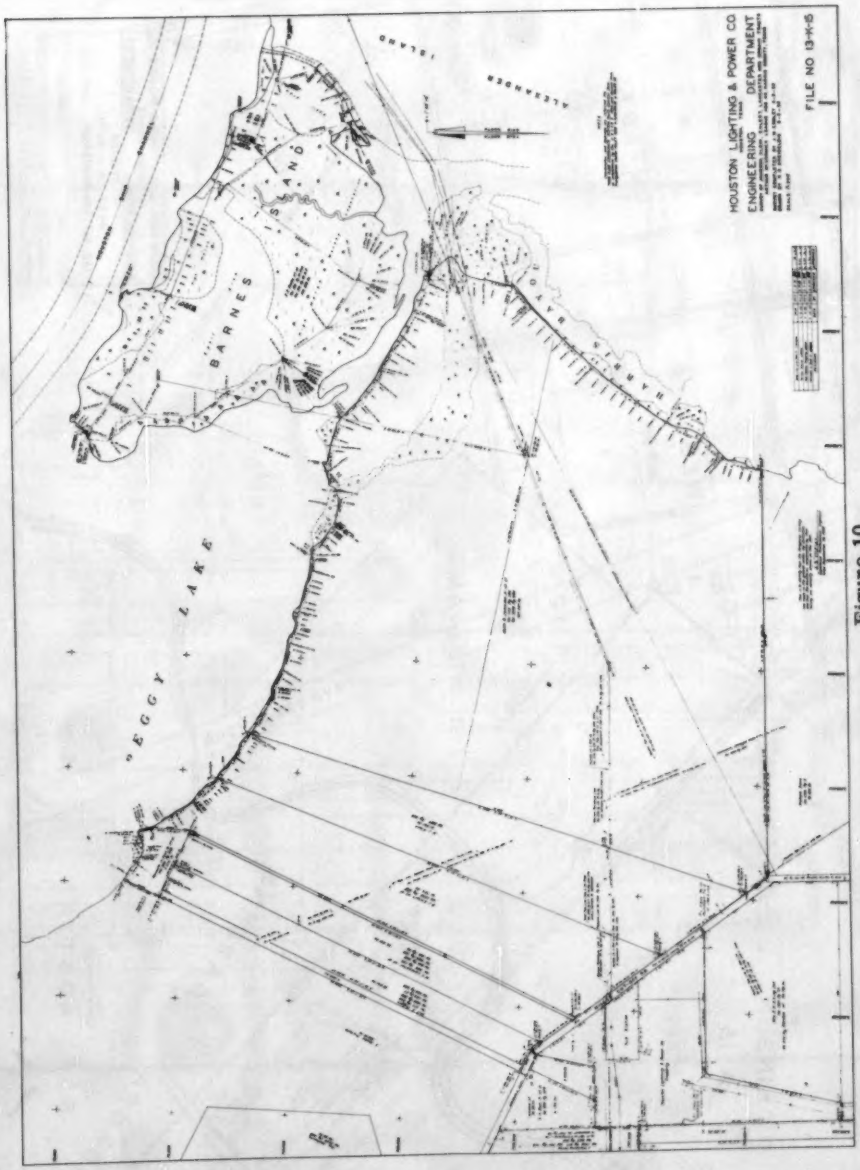

Figure 10.

Figure 9.

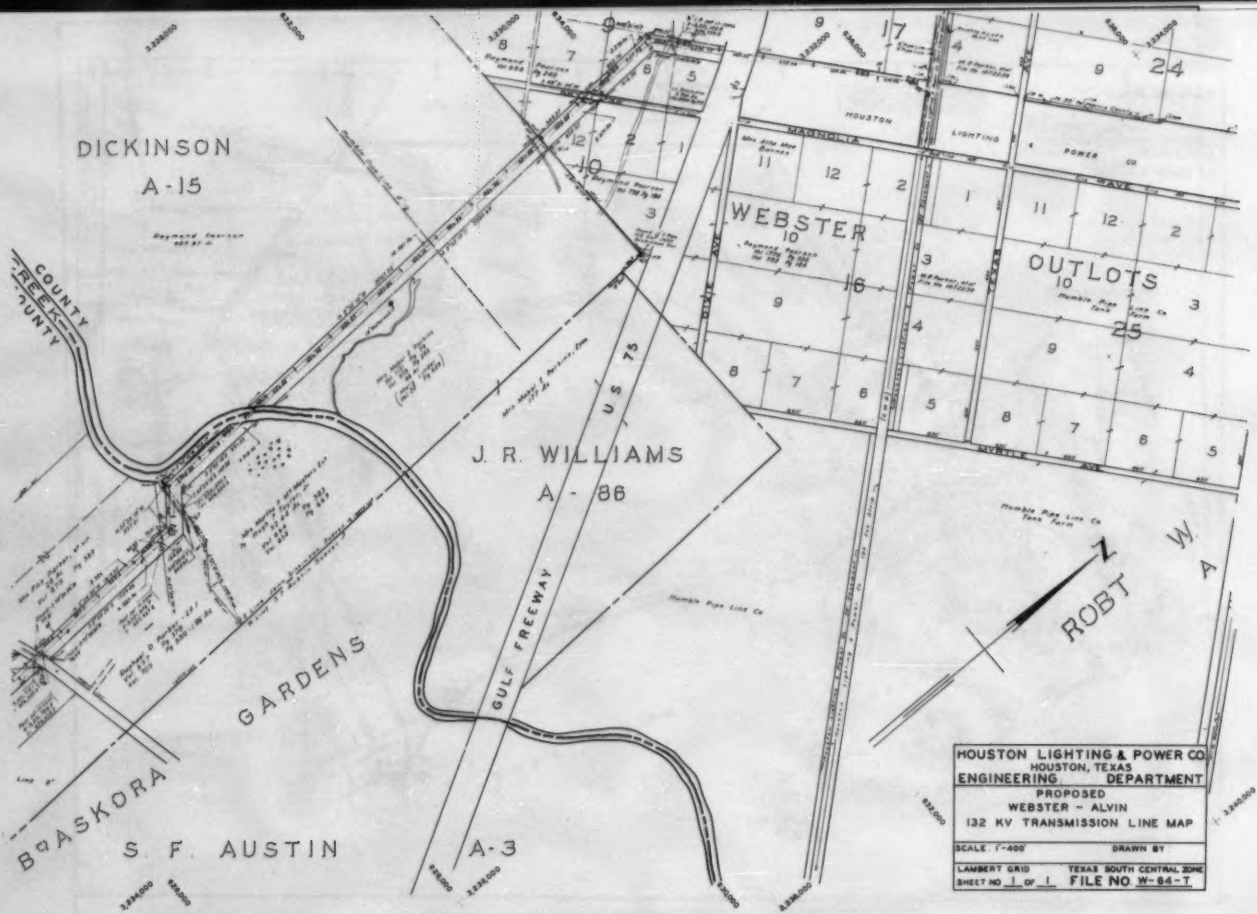

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Figure 11.

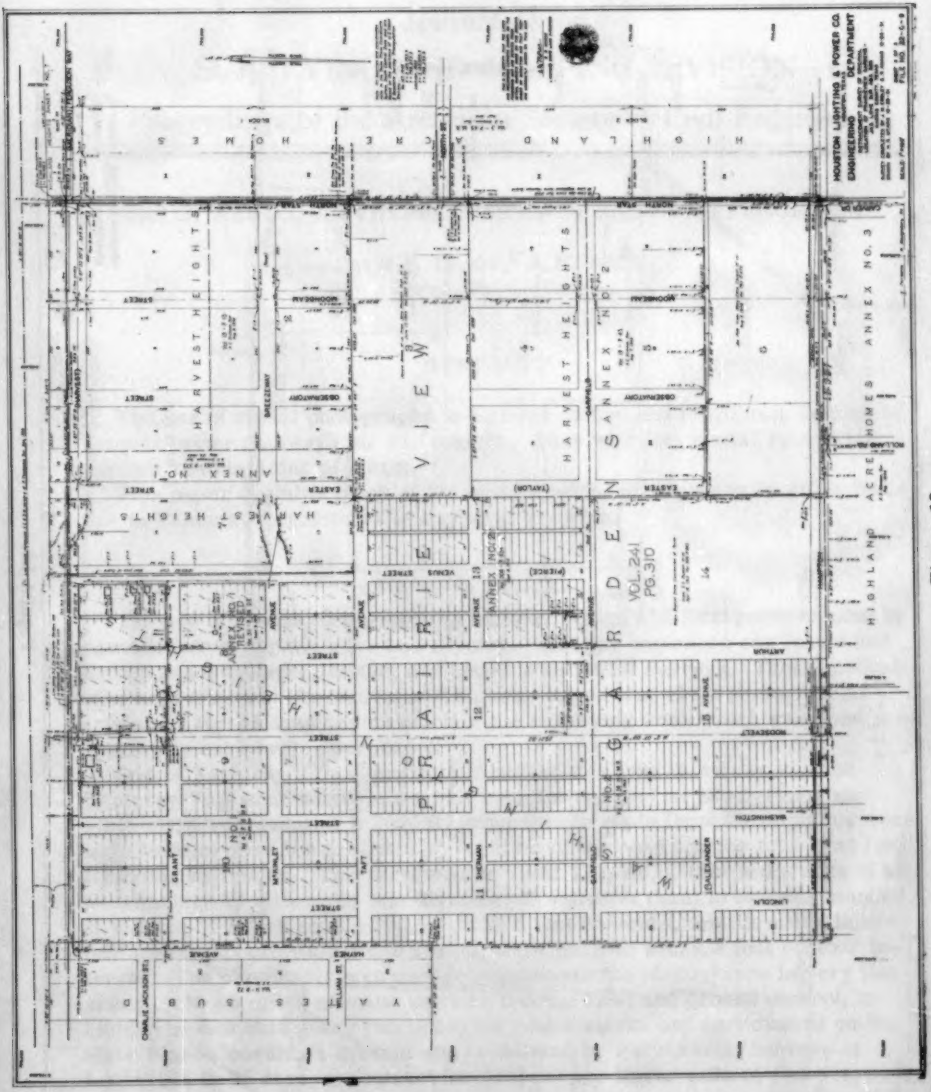

Figure 11.

Figure 12.

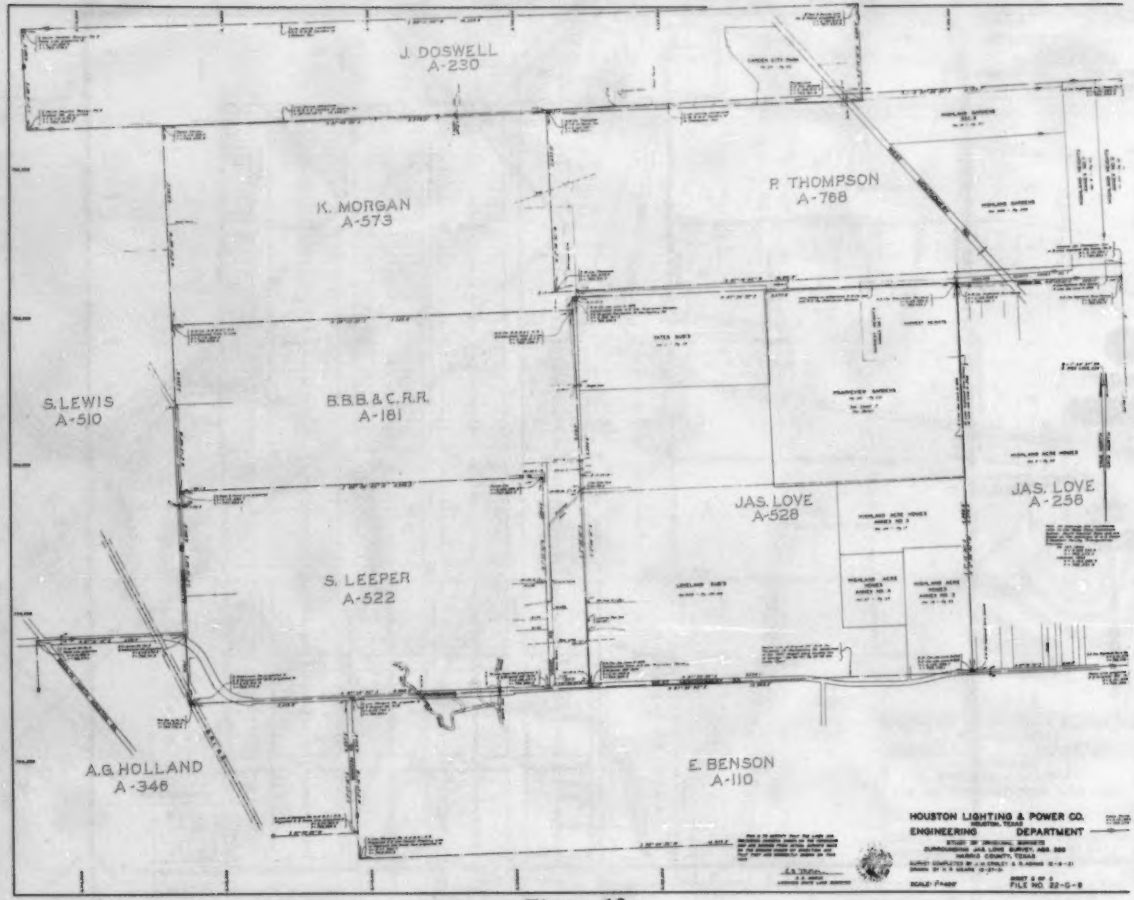
J. DOSWELL
A-230
K. MORGAN
A-573
P. THOMPSON
A-768
S. LEWIS
A-510
B.B.B. & C.R.R.
A-181
JAS. LOVE
A-528
JAS. LOVE
A-258
S. LEEPER
A-522
A.G. HOLLAND
A-348
E. BENSON
A-110
HOUSTON LIGHTING & POWER CO.
ENGINEERING DEPARTMENT

Figure 13.

Journal of the
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Proceedings of the American Society of Civil Engineers

USES OF AERIAL SURVEYING IN HIGHWAY DESIGN AND LOCATION

David K. Blythe,[1] A.M. ASCE
(Proc. Paper 1065)

ABSTRACT

The use of aerial photographs in highway design and location is helping to provide better highways for our country. They will play a vital role in the current road building program.

This paper explains some of the uses of aerial photographs by citing their use in Kentucky Department of Highways projects.

The use of aerial photographs in highway design and location is helping to provide better highways for our country. Highway engineers can locate and design roads cheaper, faster, and better with aerial surveys. These methods also help alleviate the shortage of highway engineers, since photogrammetrists and technicians can do much of the surveying work which was done previously by engineering personnel.

One of Kentucky's first projects to utilize this type of survey was the Kentucky Toll Road which is nearing completion. Aerial photographs and strip maps representing a 2000 ft. ground width made from these photos were used to determine the preliminary location of the road and the total cost for financing estimates. This total will be about $40,000,000 for a distance of approximately 40 miles. Of this distance, 36 miles in rural areas was mapped at a scale of 1 inch equals 200 feet with 5 foot contours, and 12 miles in urban areas, including alternate routes, were mapped with a 2 foot contour interval. The plane table was used to supplement the photographs in very flat areas. The 48 miles of maps on linen tracing cloth and ground control, including monuments every two miles for bench marks and coordinates on the State Plane Coordinate System was completed by Park Aerial Surveys of Louisville in 75 days by contract for $590.00 per linear mile of route mapped. This is 0.7% of the total cost. The ground control was tied into existing U. S. Geological Survey and U. S. Coast and Geodetic Survey Control.

Note: Discussion open until February 1, 1957. Paper 1065 is part of the copyrighted Journal of the Surveying and Mapping Division of the American Society of Civil Engineers, Vol. 82, No. SU 2, September, 1956.

1. Asst. Prof. of Civ. Eng., Dept. of Civ. Eng. Univ. of Kentucky, Lexington, Ky.

Figure 13.

Estimates, by location personnel of this same survey work by conventional survey methods, places the cost at two to three times that of the work by aerial photos. In addition to the excess cost, it would have been difficult for available field parties to complete the work in the same time. Aerial surveys reduce the number of personnel needed to map an area to about one fourth the number used in field surveys alone. The overall time is also reduced, especially during periods of bad surveying weather.

Illustration No. 1 shows a portion of one of these maps made from aerial photographs and No. 2 is the photo used to make the maps.

Early in 1954, the Kentucky Department of Highways created an Aerial Engineering Unit in the Division of Design. This section has been growing since its beginning and now can provide many aerial surveys for the Department. At the present time, the personnel in this section includes an aerial engineer, a design engineer who works up final plan sheets, two photogrammetrists, and one photogrammetrist's aide. Field work for the section is done by personnel temporarily assigned from regular field parties. The facilities for the Aerial Engineering Section consist of a photographic laboratory, a large copy camera, a plotting room equipped with two Kelsh Plotters,* a regular drafting room, and a map room. Up to now, Park Aerial Surveys, Louisville, takes the photographs and furnishes roll negatives for each contract. Experience has shown that it would be desirable, especially in rush jobs, for the section to have its own camera and airplane. However, with the relatively small amount of flying to be done now it is more economical to have photographs taken by contractors.

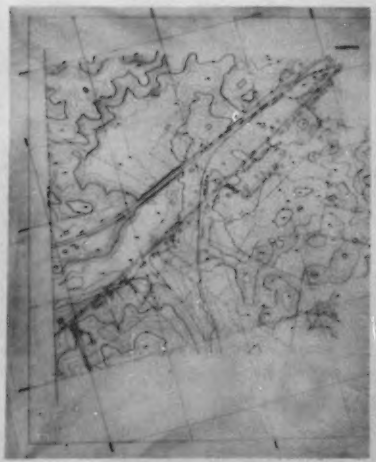

Fig. 1. Contour Map of an Area Near Elizabethtown, Kentucky

Fig. 2. Photo from which the Map in No. 1 was Made

* A Kelsh Plotter, the type instrument used in Kentucky, is a stereoscopic plotting instrument used in drawing contours on maps. Planimetric details can also be drawn with this type of instrument.

The map room just mentioned has U. S. Geological Survey maps for the entire state. These maps were made through joint efforts of the Economic Development Board of Kentucky and the Department of Highways, with the Highway Department paying a good portion of the cost. They are printed at a scale of one inch equals two thousand feet with 10 or 20 foot contours, depending on the terrain. Copies of the U.S.G.S. stereoscopic plotter manuscripts and aerial photos used to prepare these maps are also in the office files, providing excellent coverage of the entire state with both aerial photographs and maps. These maps have proven invaluable in preliminary location problems and are used extensively; however, accurate surveys must still be made for final plans. In urban areas, new photographs are needed at regular intervals to show new developments.

The most frequent assignment of the Aerial Engineering Section has been the preparation of maps for bridge sites and approach surveys for realignment and replacement of 700 sub-standard bridges. To complete this work, a group of bridge sites to be flown at one time is selected and flown by Park Aerial Surveys with the average site covered by two overlapping photographs at 1 inch equals 200 feet. If there is much vegetation on the ground or leaves on the trees, the photos are not suitable for determining elevations accurately. Photographs should be taken in the seasons when this type of obstruction to vision is at a minimum. Park Aerial Surveys submits only a set of negatives to the Aerial Engineering Section and the Section personnel make one set of glass diapositives for the Kelsh plotter and two sets of contact prints. One set of prints is usually used to make a mosaic of the area to be mapped. The manuscript map made in the plotter has a scale of 1 inch equals 40 feet, with two-foot contours. For the bridge design, this is changed to one inch equals 20 feet in the copy camera. The scale of this work sheet is then changed to 1 inch equals 100 feet after the design work is completed and traced on to the plan sheet. An illustration of this type of survey is shown below. Note existing ferry at river crossing.

Fig. 3. Map of a Cumberland River Bridge Site

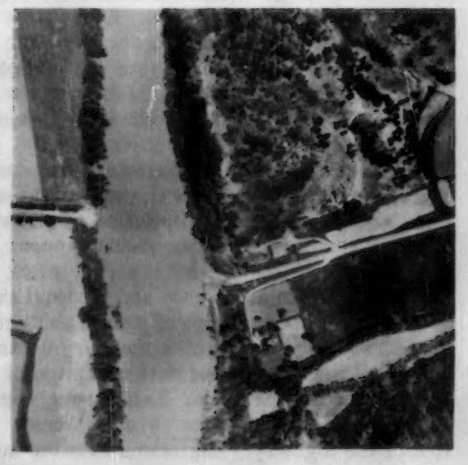

Fig. 4. Photograph of the Area Shown in No. 3

One thousand feet of this mapping will cost about $120 when the sites are worked in groups. The estimated cost for a map of the same area by field methods is $400 to $500.

The making of a topographic map with aerial photographs starts with the taking of the photos, which must have at least fifty per cent overlap in the direction of flight and about fifteen per cent sidelap. When two of these photographs are viewed stereoscopically, the overlapping area forms a three dimension model in a Kelsh-plotter. This model is controlled by field elevations and distances which can be tied to points in the photographs. The plotter has a tracing pencil which draws on the map as the photogrammetrist moves the tracing table with a pin point of light across the model. He can complete one model per day which is about one thousand feet long. This includes: control of the model in the plotter, drawing the contours, locating planimetric details, and running cross-sections.

In order to get a better idea of the actual cost of work done by the Aerial Engineering Section, expenses were kept for the mapping of a section of U. S. 31E through Glasgow, Kentucky. The summary of costs for this project which is five miles long is shown below:

Photography	$ 893.40
Ground Control	1145.70
Plotting	680.21
Tracing	280.25
Total	$2999.56

The calculated cost of preparing similar maps by ground methods, based on comparable work in other areas done in the same year, was $6,100.

An outstanding use of the aerial photographs on these jobs is the determination of cross sections mentioned before. One plotter operator can run twenty cross sections in an hour to an hour and a half, depending on the terrain. If he has good control on an existing highway to furnish centerline elevations, he can get elevations to within plus or minus 0.2 of a foot. This has been verified by field checks. Experience has shown that the ground must be visible in the photos for this accuracy. It is apparent that weed fields which show only the tops of the plants in the photograph, would cause errors in the determination of elevations. Adjustments must be made for this by field checks or scheduling of flights in the seasons to avoid the problem as suggested before.

It can be seen that a disadvantage of mapping with aerial photos is that it is difficult to schedule the flights for the weather and seasons. As an advantage, ground control is simplified in highway mapping with photographs since existing roads and bridges usually appear in the photographs and plans can furnish part of the ground control. Also, it simplifies field measurements to be able to run horizontal and vertical control along the existing roads.

Another important use of aerial photographs is known as photo-interpretation. This does not involve measurements on the photographs in the usual sense but pertains to the determination of rock and soil conditions beneath the surface by inference. Landforms, vegetation, drainage patterns, color and other characteristics reveal valuable information concerning the foundation of the highway. Engineers with the necessary background and training determine these factors and can recommend the best route at the very beginning of a project.

Photographs can be enlarged and provide a valuable aid in the acquisitions

Fig. 5. Aerial Photograph of an Area in Limestone Terrain in Kentucky. Sinkholes are Visible Near the Arrows. Note the Action of the River.

of right of way. The owners can readily see, on photos, where a proposed road is to be located and thus may discuss the transaction with better understanding.

These are not all the uses that can be made of aerial photographs in Highway Engineering. Only the imagination and training of engineers and photogrammetrists limit the application of aerial photos to design and location problems. They are another tool which will enable highway engineers to build roads better and cheaper as the U. S. Highway Program is expanded under the stimulus of current legislation. Kentucky will use aerial photographs more in the future as the Aerial Engineering Section grows in size and experience.

Journal of the
SURVEYING AND MAPPING DIVISION
Proceedings of the American Society of Civil Engineers

CONTENTS

DISCUSSION
(Proc. Paper 1066)

Note: Paper 1066 is part of the copyrighted Journal of the Surveying and Mapping Division of the American Society of Civil Engineers, Vol. 82, No. SU 2 September, 1956.

Discussion of
"PROFESSIONAL ASPECTS OF SURVEYING AND MAPPING"

by B. Austin Barry
(Proc. Paper 921)

SUMNER B. IRISH,[1] A.M. ASCE.—The report of the Task Committee on the status of surveying and mapping represents a great deal of work and thought by the three men on the Committee. The writer believes that it has been significant work and will be quoted and referred to for a long time to come. It is important, if for nothing else, in that it has brought together various ideas and thoughts as to what constitutes professional work in its many ramifications. A yardstick to measure professional work has been presented, and it is applicable to all types of engineering, not just civil engineering, not just surveying and mapping.

For those directly involved in surveying and mapping, the classification of positions will be most helpful in setting up organizations and in determining the titles to be used for professional-level work and for technician-level work. Of course the title of a job will not determine in the last analysis whether or not professional-level work is being done by a person with such a title. As a matter of fact, this appears as one of the big problems in the discussion of the word "professional."

In the surveying and mapping field, variations in work done under one title reaches its zenith in the designation "party chief," which has probably not been included in the classification of positions for that very good reason. In some cases the party chief has full responsibility for the designing of the surveys involved, the selection of equipment to do the job, and the supervision of the technicians who actually do the work. In other cases, the party chief is merely the supervisor of the party in the field and is in reality a glorified instrument man. While it might be well to dispense with the title "party chief" because of the wide variations in its meaning, some replacement for this time-honored name should be found.

The defining of photogrammetry as a technique or tool, albeit a rather important and extensive one, and not as a major branch or category of surveying is unquestionably in order. The use of photogrammetry is comparable to the use of mathematics, geophysics and the like in surveying and mapping work. These fields of knowledge facilitate the accomplishment of the work, but by themselves they could not carry through any job.

A viewpoint which might be used in considering photogrammetry (and its recognition as a technique similar to mathematics and geophysics) is that of its true technological roll. As the above mentioned two disciplines have wide application not limited to surveying and mapping, so also does photogrammetry have much wider application than to the one specific field under consideration. Photogrammetry involves the graphical recording of data both quantative and qualitative for analysis at a later time. Map making is an ideal use,

1. Dept. of Eng., Princeton Univ., Princeton, N. J.

but is just one of its many uses. Therefore, it seems unwarranted to describe the photogrammetrist in the manner he has been, which by inference limits him to surveying and mapping. If he is given a position description, so also should the mathematician and geophysicist.

Further, with regard to photogrammetry, it might be mentioned that registration laws to specifically cover maps made by photogrammetric means seem out of order. The problems encountered in the making of a map remain as before. Accuracy and reliability standards should be the same regardless of the methods used to accomplish the job. Thus, to accommodate photogrammetrically made maps, no change in registration laws seems necessary.

Perhaps the most valid viewpoint from which this writer can discuss this paper is that of an educator in the civil engineering field, inasmuch as he is thus normally employed. The approach he will use is to consider each one of the professional positions defined, except the photogrammetrist for the reason stated above, with regard to the curriculum in a typical university civil engineering department, in an effort to determine how well it does or does not fit into the ordinary concept of a university civil engineering program.

First consider survey engineer, geodetic surveyor, control surveyor, and topographer, positions for which the usual college civil engineering graduate should be prepared. Probably the engineering surveys for design and construction as done by the survey engineer is the term in which the surveying educator most logically thinks and the branch for which he can most readily establish a need. It goes without saying that the engineering surveys are the heart and soul, the foundation of any civil engineering project. At the same time, the fundamentals which are put in the college courses should provide the basis for a graduate to fulfill competently the position of geodetic surveyor and control surveyor. Also much stress has customarily been put on topography in the normal course of instruction, and it will undoubtedly continue to be so for some time to come. Incidentally, it is one of the best ways for a student to physically comprehend some of the results from the course work he is doing. Thus, it can be safely said that the four positions mentioned above are taken care of in the usual civil engineering undergraduate programs.

With regard to the cartographer and map editor, little work is ordinarily given in a civil engineering department that would equip the graduate to hold a position in these categories. The work in cartography covered in the average undergraduate program is superficial at best. It, at the present, seems rather far removed from the ordinary goal of the civil engineering program. Unquestionably there is a need for course work in this field, but should it be included in the civil engineering curriculum? The writer thinks not, except possibly as an elective or graduate course. Thus he has difficulty in justifying the inclusion of these professional positions in the surveying and mapping field, and consequently within the province of the American Society of Civil Engineers.

A man well-trained in a geography department at some university would possibly be best qualified to do cartographic work as outlined in this classification of positions. One is tempted to say that cartography is not the sort of thing in which the ordinary engineer is interested. The difference in approach to problems between the engineer and the scientist is well known. There is room for both. Similarly, the approach of the geographer is different from that of the engineer. There is room for both of them also.

The situation of the land surveyor is far less clear and less well understood. As pointed out in the position description, his work includes the layout

of roads, streets and rights of way. Such work is unquestionably best handled from a civil engineering background. Another problem which is becoming more and more important in much of the work of the land surveyor, particularly in subdivision layouts, is that of drainage. He should have a background to handle this also. This again is a typical civil engineering function.

On the other hand, the determination of land boundaries is an extremely technical matter which few if any civil engineers are capable of comprehending at the time of graduation from the average civil engineering program. Legal aspects are involved which cannot possibly be covered in a university civil engineering curriculum, except in the most specialized ones. The writer doubts, however, that the future will see much change in this situation.

There is no question but that there is a need for competent, professional land surveyors, but is the ordinary civil engineer prepared to go into this work? If he is not, how does the land surveyor acquire the necessary preparation and background, and is it something the civil engineering profession can expect him to acquire when he is a full-fledged civil engineer? The land surveyor needs a civil engineering background for the work enumerated in a previous paragraph, but he also needs something which the civil engineering schools do not seem capable of offering him. This poses somewhat of a dilemna as far as this writer is concerned.

Summarizing, the writer believes that engineering surveys, geodetic surveying and cartographic surveying are fields which are peculiar to surveying and mapping as customarily considered within a civil engineering framework. Aerial survey services, which involve techniques not peculiar to civil engineering, and cartography, which can probably be handled just as well by someone trained in another discipline, do not of necessity belong in the civil engineering classification of surveying and mapping. They are optional classifications. On the other hand, land surveying involves some special problems which at the moment are not completely resolved. Some of these are civil engineering problems, but others are legal problems, with the latter possibly predominating. Where land surveying fits into the picture the writer is not at all certain.

In closing, a hearty vote of thanks to the Task Committee for shaping up a report which promises to be talked about and discussed for some time to come.

WILLIAM A. WHITE,[1] A.M., ASCE.—The report on professional aspects of surveying and mapping provides us with an excellent analysis of the fields of surveying with appropriate titles for the practitioners in the various fields. This is in addition to its intended, and accomplished, purpose of delineating the professional grades of surveyors and mappers. The report should be a valuable adjunct to statutory and administrative definitions used by Boards of Registration in evaluating applications for licensure or registration. It should serve as an excellent guide to personnel departments in governmental and large private organizations to rationalize job classifications and salaries. It could serve Registration Boards and Civil Service agencies in selecting appropriate examination questions to accomplish the desired effect. When generally accepted, the analysis will probably have some effect on labor union

1. Executive Secretary, California Council of Civil Engrs. and Land Surveyors, Room 811, Forum Bldg., Sacramento, Calif.

problems, new legislation, education, contracting of public works, and many other matters.

The foreword contains an appropriate discussion of the place of photogrammetry as a technique in, rather than a branch of, surveying and mapping. This was a live issue in California in 1954. The California Legislature in 1955 considered a bill that would have exempted from the mandatory licensing requirement surveys made using photogrammetric techniques. The bill died in committee. A court case related to this subject was initiated in 1954 and has not yet been settled, with hearings scheduled to be resumed in September, 1956.

The three definitions of "professional" furnished in the foreword are necessary to the analysis. Some definition of "professional" must be used in conjunction with the Definitions of Professional Positions furnished later in the report, in order to completely define the professional positions. For instance, the land surveyor's work must call for "discretion and judgment" (Attribute No. 2 of the Engineers Council for Professional Development definition) if it is to be of professional grade. A California court case furnishes another example. A non-licensed person prepared plans for a city hall. The plans were not competently done and building contractors' bid prices were high. The City Council then engaged a registered engineer to redesign the building. The non-licensed man was brought into court on a charge of practicing civil engineering without being registered. His plans were submitted as evidence. An expert witness, when asked if the plans constituted civil engineering practice, expressed the opinion that they were not civil engineering plans, they were only an attempt at civil engineering. The judge declared the man not guilty of practicing civil engineering. The point is that the professional positions defined in the report are only professional when practiced or performed in a professional manner. In this regard, every one of them is capable of meeting the requirements set forth by ECPD.

The definition of Survey Engineer furnished in the report is skimpy to the point of slighting that ancient and honored profession. The engineer who surveys for design, for location, for supervision of construction, for estimates, for inspection, for change orders, etc., is the direct descendant of the original civil engineer. Every construction project is dependant on him for its success. Certainly when practiced with the attributes set forth by ECPD for a professional, the work of the Survey Engineer is professional.

DIVISION ACTIVITIES
SURVEYING AND MAPPING DIVISION
Proceedings of the American Society of Civil Engineers

NEWSLETTER

September, 1956

SURVEYING AND MAPPING DIVISION PLANS FOR PITTSBURGH CONVENTION

Thursday, October 18, 1956

A.M. Technical Session - S&M Division

Thursday Noon - Joint Luncheon with Highway and Soil Mechanics and Foundations Divisions. Speaker Rex M. Whitton, Chief Engineer of the Missouri State Highway Department and President of the American Association of State Highway Officials, will discuss national highway affairs.

P.M. Open Meeting of the Executive Committee, S&M Division

The Technical Session on Thursday morning will include three papers on timely subjects: George H. Harding on Land Survey Problems in the Philippines; William O. Baker on the Application of Photogrammetry to Civil Engineering Problems; and Robert A. Cummings, Jr. on City Surveys.

Mr. Whitton, the luncheon speaker, is well qualified to bring us up to date on the steps being taken to implement the expanded highway construction program.

All members of the Surveying and Mapping Division are also cordially invited to attend and take part in the open meeting of the Executive Committee on Thursday afternoon. The agenda includes a report by the Professional Status Committee, the newly formed Research Committee, and the reorganized Highway and Bridge Surveys Committee. In addition to reports of the Technical Committees the subject of a Bachelors Degree in Surveying will be discussed and the previous resolution on the U. S. Civil Service Engineer Cartographer classification.

Plan to attend the Pittsburgh Convention
October 15-19, 1956

* * * * *

Resume of Executive Committee Meeting on October 24, 1955

Twenty members and guests were present at the Executive Committee meeting of the Surveying and Mapping Division of the Society held at the Statler Hotel in New York City on October 24, 1955. Those present included: R. H. Lyddan, Chairman; Carl M. Berry, Member; Milton O. Schmidt, incoming Member; Oscar C. J. Marshall, Member; Benjamin E. Beavin, Sr., Member; Lansing G. Simmons, Member; Earle J. Fennell, Secretary; George D. Whitmore; Lewis A. Dickerson; Bro. B. Austin Barry; William L. White; Frank Patten; A. O. Quinn; Albert J. Hoskinson; Page F. Hopkins; Philip Kissam; Sol A. Bauer, Chairman, Committee on Land Surveys and Titles; Harmer A. Weeden; Paul Rice; Daniel Kennedy, Chairman, Committee on Topographic Mapping and Photogrammetry.

R. H. Lyddan, Chairman of the Executive Committee, presided, and the following are some of the highlights of the items discussed and action taken at the meeting.

The revision of Manual No. 10, "Technical Procedure for City Surveys," has been completed by the Committee on City Surveys and the manuscript will now be reviewed by Oscar C. J. Marshall and Carl M. Berry of the Executive Committee. (Ed. note: Publication will take place this fall.)

Brother B. Austin Barry reviewed the work of the Task Committee on the Status of Surveying and Mapping appointed by the Executive Committee in October 1954 and presented a report entitled, "Professional Aspects of Surveying and Mapping." Brother Barry stated that the scope of the present report is merely to achieve a distinction between the professional level and the technical level on activity in surveying and mapping, with a brief note regarding pre-professional work. Further study will be needed to delineate adequately the activities which properly constitute engineering. Basic definitions of the terms professional, pre-professional, and technical are given in the report followed by classification of the principle positions in surveying and mapping to serve as a fundamental basis for further study.

After a discussion of the report a motion was adopted to accept the report of the Task Committee for further review with the Committee on Professional Practice. A motion to continue the work of the Task Committee was unanimously adopted. (The report of the Task Committee was published in the first issue of the Journal of the Surveying and Mapping Division as No. SU1, dated March 1956.)

Chairman Beavin suggested that the Division poll the local sections for candidates for technical committee memberships.

The Technical Publications manager, Mr. Harold Larson, joined the meeting for a brief discussion of new Society policies on the distribution of Separates and other publications. Complete information on these will be sent out from the New York Office. Mr. Larson stated that a current list of members, who have indicated interest in the activities of a specific Division, will be sent bi-annually to the Secretary of each Division. He also advised that there will be a journal available for publication of material from the Surveying and Mapping Division. (First issue published March 1956.)

Milton O. Schmidt, Chairman, reported slow but satisfactory progress in the formation of the new Committee on Highway and Bridge Surveys. He has reviewed the background and accomplishments of the Committee on Highways of the American Congress on Surveying and Mapping, headed by J. C. Carpenter, which convinced him of the need to select committee members carefully. Mr. Schmidt reported that this Committee on Highway and Bridge

Surveys could well represent the collective action of both the Survey and Mapping Division and the Highway Division. He has therefore contacted Mr. Roy E. Jorgenson, Chairman of the Highway Division, who has given him some leads on highway engineers in both government and private practice who might serve as effective members on this Committee.

Mr. Simmons suggested Tracy Atherton, Carl M. Berry, Oscar C. J. Marshall, Paul Rice and Julius L. Speert as candidates for Chairman of the Committee on Control Surveys. Mr. Speert was selected.

A discussion was held on the advisability of changing the purpose of the Committee on Topographic Mapping and Photogrammetry to provide for the preparation of a bibliography of material of surveying, mapping, and photogrammetry, and to add the following: "Act as a committee to answer questions on topographic mapping and photogrammetry." A motion was adopted that the Executive Committee explore the possibility of modifying the responsibilities of the Committee on Topographic Mapping and Photogrammetry to allow the foregoing.

The matter of a Newsletter for the Division was discussed and the general view is still in favor of such a Newsletter. The concensus present favored continuing the work done to date by Professor Irish and furnishing him with more help. The Secretary and Chairman were asked to take further action in this regard.

Mr. Carl M. Berry said that he felt the Executive Committee should consider some means of assisting Federal Agencies such as the Coast and Geodetic Survey in recruiting Civil Engineering graduates. Professor Kissam suggested sending ASCE representatives to colleges with lists of jobs which are to be filled from government and other agencies which cannot afford to send representatives of their own. The "Dutch Uncle" idea of attracting high school graduates into Civil Engineering was reviewed by Mr. Berry. No action was taken on this item.

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The Committee on Division Activities has approved the recommendation of the Executive Committee for the formation of a committee on Research in the Surveying and Mapping Division. Chairman Beavin has appointed Harmer A. Weeden to serve as Chairman and the committee is in the process of being formed.

The Committee on Highway and Bridge Surveys of the Surveying and Mapping Division was reactivated in January 1956 and contains the following members:

1) Oliver R. Bosso, Engineer of Surveys, Division of San Francisco Bay Toll Crossings, California Department of Public Works
2) R. H. Dodds, Development Engineer,—Lockwood, Kessler & Bartlett, Inc.
3) R. A. Haber, Chief Engineer, Delaware Highway Department
4) Peter A. Hakman, Assistant Chief Field Engineer, Parson, Brinckerhoff, Hall & MacDonald
5) A. A. Katterhenry, Assistant Professor of Civil Engineering, University of Florida
6) John G. McEntyre, Associate Professor of Civil Engineering, Kansas State College
7) C. A. Rothrock, Engineer of Preliminary Location and Design, Ohio Department of Highways

8) L. R. Schureman, Chief, Engineering Development and Special Assignments Sections, U. S. Bureau of Public Roads
9) Milton O. Schmidt (Chairman), Professor of Civil Engineering, University of Illinois

The Committee has selected as its goal the preparation of a manual on technical procedure for highway surveys. It is anticipated that the several chapters of the proposed manual will be released in preliminary form as separates. It seems likely that the first one will be on state plane coordinates.

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The State of Washington establishes a Division of Surveys and Maps.

Under the provisions of an enabling act passed in 1951 by the Washington State Legislature, a new Division of Surveys and Maps has been established in the Department of Public Lands. The Division will operate a map library and information agency which it is believed will be the first such agency on the state level in the United States. The Enabling Act establishes a new Division of Surveys and Maps as a division of the Engineering Department of Public Lands. Chief Engineer of the Department is Marvin E. Bowler.

Under Commissioner Otto A. Case, the Department of Public Lands is charged with the administration and control of all State public lands, which comprise about one-seventh of the land area of Washington. The mission of the new agency is to act as a coordination center for both public and private surveying and mapping activities in the State, to operate a library of surveying and mapping information, including files of maps and indices of sources of surveys and maps, to keep records of monuments and to provide a means for preservation and restoration of monuments, corners and references, to promote the more extended use of control surveys, the State coordinate system and better methods of surveying and mapping generally.

Appointed by the Commissioner of Public Lands to assist in the formulation of policy is a five-man advisory board headed by Captain A. M. Sobieralski, well-known retired Coast Survey Officer and one of the pioneers of this work. Other members of the board are C. V. Payne, Registered Land Surveyor of Spokane, I. Curtiss Parker, recently retired senior partner of Parker, Hill and Ingman, of Seattle, Carl M. Berry, well-known consulting engineer of Seattle, and Professor Hiram M. Chittenden of the surveying section of the Department of Civil Engineering at the University of Washington.

Newly-appointed head of the Division of Surveys and Maps is Burton R. Ingalls, formerly design engineer for the City of Bellingham, Washington. Mr. Ingalls recently has returned from a one-month tour of eastern states where he conferred with experienced survey engineers and bureau chiefs who long have felt the need for this type of agency. It is hoped that the Division of Surveys and Maps will be able to test the soundness of ideas developed in these conferences.

Test programs include new methods of cataloguing surveys and maps, microfilm storage of data, improved techniques for filing and storing full-sized maps, a pilot project utilizing resection as a means for extending control surveys, the utilization of the State coordinate system for map and survey indexing and research into the methods for making the Torrens title more effective and more universally used.

Reported by Carl M. Berry, Member of the Executive Committee.

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Daniel Kennedy, Chairman of the Committee on Topography and Photogrammetry, writes:

"With the increased use of mapping by the highway departments in both location and earthwork problems, civil engineers are going to need more training in surveying and mapping in the colleges. Several State highway departments are developing aerial survey sections within their organizations which will further increase the demand for better trained graduates in the basic civil engineering courses. This should have a beneficial effect toward halting the trend that caused many schools to cut down on the surveying and mapping subjects taught in the civil engineering course.

"In talking with a commercial photogrammetrist not long ago, he made the statement that if the professional photogrammetrist did not soon awaken to his responsibilities, he would find that the professional engineers had taken over photogrammetry. That's certainly a new twist in thinking, for I had always considered photogrammetry an instrument of civil engineering."

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The 1956 ACSM-ASP Regional Convention and Co-Exhibit will be held at the Shirley-Savoy Hotel, Denver, Colorado on September 30-October 2, 1956. For further information, contact Stanley M. Borrell, Convention Chairman, Box 1407, Edgewater Branch, Denver 14, Colorado.

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The August 1955 (No. 6) issue of the JOURNAL of the U. S. Coast and Geodetic Survey is a 190-page publication containing many interesting papers on the operations of the C&GS and related subjects.

ACSM-ASP Annual Meetings

Seventeen hundred people registered for the Consecutive Meetings and Co-Exhibit of the American Congress on Surveying and Mapping and the American Society of Photogrammetry held in Washington, D . C. during the week of March 18-24, 1956. In this cooperative program each organization provided a full schedule of meetings which were independent with respect to the organizations but unified in purpose. Sixty-three exhibits by commercial firms or government agencies were on display offering equipment, materials and services. A report of the proceedings is published in the current issues of SURVEYING AND MAPPING of the ACSM and PHOTOGRAMMETRIC ENGINEERING of the ASP.

Plans are underway for similar Consecutive Annual Meetings and Co-Exhibits of these societies to be held at the Shoreham Hotel, Washington, D. C. during the week of March 3-9, 1957.

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George D. Whitmore and Conrad A. Ecklund attended the International Congress and Exposition of Photogrammetry at Stockholm, Sweden on July 17-26, 1956. Mr. Whitmore presented a paper entitled "Economic Factors in the Integrated Photogrammetric System of the U. S. Geological Survey."

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The American Society of Photogrammetry has moved to new quarters in the recently completed building of the American Association for the Advancement of Science at 1515 Massachusetts Avenue, N.W. in Washington, D. C. Other occupants of this modern structure include the American Geophysical Union, the American Geological Institute and some sections of the American Chemical Society.

* * * * *

Electronic Computers to speed highway program

Several conferences on the general subject of increasing highway engineering productivity have been held during the past year. These meetings, sponsored by the American Association of State Highway Officials, the Bureau of Public Roads and many others, are seeking improved methods and procedures for solving highway problems. Many of these studies are in the field of surveys and design, such as methods which will provide a direct connection between precision stereoplotters and electronic computers. The newly organized Technical Committee on Highway and Bridge Surveys will keep in close touch with these developments through several of its members who are involved in these studies.

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Specifications for Aerial Surveys and Mapping

A Reference Guide Outline for Specifications for Aerial Surveys and Mapping for Highways has just been issued by the Bureau of Public Roads. This report was prepared by the Photogrammetry for Highways Committee jointly sponsored by the American Society of Photogrammetry and the American Congress on Surveying and Mapping under the direction of William T. Pryor, Chairman. This reference guide is designed to be particularly helpful in the preparation of specifications for aerial photography and topographic maps at scales of 1000 feet to the inch or larger. The report does not include small scale maps, such as the standard quadrangle maps (scale 1:24,000 or 1:62,500) which are generally available for preliminary reconnaissance of possible routes. The report does include the various large scale maps and surveys usually required for analysis of alternate routes and highway design.

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Editorial Note.

No doubt there are many activities in which readers of this Newsletter are engaged, such as special conferences and publication of their proceedings in which S&MD members would be interested. Your editor will endeavor to list such items as they are received, subject to the S&MD Executive Committee policy.

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW) divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper numbers are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 861 is identified as 861 (SM1) which indicates that the paper is contained in issue 1 of the Journal of the Soil Mechanics and Foundations Division.

VOLUME 81 (1955)

SEPTEMBER: 787(PO), 788(IR), 789(HY), 790(HY), 791(HY), 792(HY), 793(HY), 794(HY)[c], 795(EM), 796(EM), 797(EM), 798(EM), 799(EM)[c], 800(WW), 801(WW), 802(WW), 803(WW), 804(WW), 805(WW), 806(HY), 807(PO)[c], 808(IR)[c].

OCTOBER: 809(ST), 810(HW)[c], 811(ST), 812(ST)[c], 813(ST)[c], 814(EM), 815(EM), 816(EM), 817(EM), 818(EM), 819(EM)[c], 820(SA), 821(SA), 822(SA)[c], 823(HW), 824(HW).

NOVEMBER: 825(ST), 826(HY), 827(ST), 828(ST), 829(ST), 830(ST), 831(ST)[c], 832(CP), 833(CP), 834(CP), 835(CP)[c], 836(HY), 837(HY), 838(HY), 839(HY), 840(HY), 841(HY)[c].

DECEMBER: 842(SM), 843(SM)[c], 844(SU), 845(SU)[c], 846(SA), 847(SA), 848(SA)[c], 849(ST)[c], 850(ST), 851(ST), 852(ST), 853(ST), 854(CO), 855(CO), 856(CO)[c], 857(SU), 858(BD), 859(BD), 860(BD).

VOLUME 82 (1956)

JANUARY: 861(SM1), 862(SM1), 863(EM1), 864(SM1), 865(SM1), 866(SM1), 867(SM1), 868(HW1) 869(ST1), 870(EM1), 871(HW1), 872(HW1), 873(HW1), 874(HW1), 875(HW1), 876(EM1)[c], 877 (HW1)[c], 878(ST1)[c].

FEBRUARY: 879(CP1), 880(HY1), 881(HY1)[c], 882(HY1), 883(HY1), 884(IR1), 885(SA1), 886(CP1), 887(SA1), 888(SA1), 889(SA1). 890(SA1), 891(SA1), 892(SA1), 893(CP1), 894(CP1), 895(PO1) 896(PO1), 897(PO1), 898(PO1), 899(PO1), 900(PO1), 901(PO1), 902(AT1)[c], 903(IR1)[c], 904 (PO1)[c], 905(SA1)[c].

MARCH: 906(WW1), 907(WW1), 908(WW1), 909(WW1), 910(WW1), 911(WW1), 912(WW1), 913 (WW1)[c], 914(ST2), 915(ST2), 916(ST2), 917(ST2), 918(ST2), 919(ST2), 920(ST2), 921(SU1), 922(SU1), 923(SU1), 924(ST2)[c].

APRIL: 925(WW2), 926(WW2), 927(WW2), 928(SA2), 929(SA2), 930(SA2), 931(SA2), 932(SA2)[c], 933(SM2), 934(SM2), 935(WW2), 936(WW2), 937(WW2), 938(WW2), 939(WW2), 940(SM2), 941 (SM2), 942(SM2)[c], 943(EM2), 944(EM2), 945(EM2), 946(EM2)[c], 947(PO2), 948(PO2), 949(PO2), 950(PO2), 951(PO2), 952(PO2)[c], 953(HY2), 954(HY2), 955(HY2)[c], 956(HY2), 957(HY2), 958 (SA2), 959(PO2), 960(PO2).

MAY: 961(IR2), 962(IR2), 963(CP2), 964(CP2), 965(WW3), 966(WW3), 967(WW3), 968(WW3), 969 (WW3), 970(ST3), 971(ST3), 972(ST3)[c], 973(ST3), 974(ST3), 975(WW3), 976(WW3), 977(IR2), 978(AT2), 979(AT2), 980(AT2), 981(IR2), 982(IR2)[c], 983(HW2), 984(HW2), 985(HW2)[c], 986(ST3), 987(AT2), 988(CP2), 989(AT2).

JUNE: 990(PO3), 991(PO3), 992(PO3), 993(PO3), 994(PO3), 995(PO3), 996(PO3), 997(PO3), 998 (SA3), 999(SA3), 1000(SA3), 1001(SA3), 1002(SA3), 1003(SA3)[c], 1004(HY3), 1005(HY3), 1006 (HY3), 1007(HY3), 1008(HY3), 1009(HY3), 1010(HY3)[c], 1011(PO3)[c], 1012(SA3), 1013(SA3), 1014(SA3), 1015(HY3), 1016(SA3), 1017(PO3), 1018(PO3).

JULY: 1019(ST4), 1020(ST4), 1021(ST4), 1022(ST4), 1023(ST4), 1024(ST4)[c], 1025(SM3), 1026 (SM3), 1027(SM3), 1028(SM3)[c], 1029(EM3), 1030(EM3), 1031(EM3), 1032(EM3), 1033(EM3)[c].

AUGUST: 1034(HY4), 1035(HY4), 1036(HY4), 1037(HY4), 1038(HY4), 1039(HY4), 1040(HY4), 1041(HY4)[c], 1042(PO4), 1043(PO4), 1044(PO4), 1045(PO4), 1046(PO4)[c], 1047(SA4), 1048 (SA4)[c], 1049(SA4), 1050(SA4), 1051(SA4), 1052(HY4), 1053(SA4).

SEPTEMBER: 1054(ST5), 1055(ST5), 1056(ST5), 1057(ST5), 1058(ST5), 1059(WW4), 1060(WW4), 1061(WW4), 1062(WW4), 1063(WW4), 1064(SU2), 1065(SU2), 1066(SU2)[c], 1067(ST5)[c], 1068 (WW4)[c], 1069(WW4).

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c. Discussion of several papers, grouped by Divisions.

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